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Science Fair ®

RadioShack.

CAUTION!

For use by children over 8 years old. Read instructions before using. Follow the directions, and keep them for reference.

Advice for supervising adults:

Read and follow the safety instructions. Supervising adults should discuss any warnings, cautions, and safety rules with children before starting the project.

Safety Rules:

1. Read the directions before using. Follow all directions and keep them for reference.
2. Keep young children and animals away from the area while you are assembling the project.
3. Store the project out of reach of small children and animals.

Hint: Words printed in boldface are defined in the Glossary at the back of this Owner's Manual.

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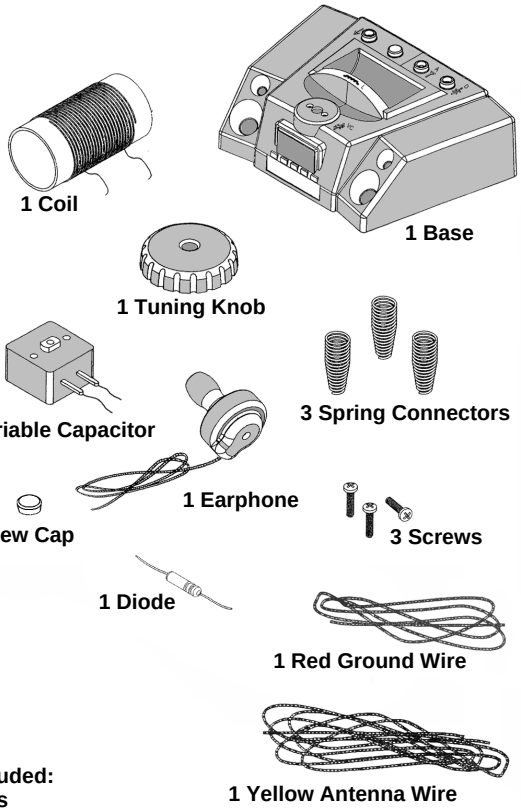
Your crystal radio kit contains the following items:



Also Included:
2 Stickers

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ABOUT THIS MANUAL

RADIO TECHNOLOGY ..... Page 5
Describes people involved in early crystal radio development.

BASIC ELECTRONIC SYMBOLS .....Page 6
Explains the electrical parts of a crystal radio.

MAKING THE CONNECTIONS .....Page 8
Step-by-step instructions for putting the crystal radio together.

OPERATION..... Page 18
Tells you how to use the crystal radio.

TROUBLESHOOTING ..... Page 19
Describes typical crystal radio problems and solutions.

UNDERSTANDING RADIO TECHNOLOGY ..... Page 21
Explains the basic principles behind sending and receiving radio waves.

FACTS ABOUT RADIO .....Page 25
Offers more details about Gugliemo Marconi and what he discovered about radio waves.

MORSE CODE .....Page 29
Provides the actual code used by many radio operators.

GLOSSARY..... Page 31
Lists the technical words used throughout this manual and provides their definitions for easy reference.

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RADIO TECHNOLOGY

Facts About Early Crystal Development

A **crystal detector** is a device that can pass **current** in an electrical **circuit** in one direction better than the other. This idea is attributed to several inventors. In the 1870s, Karl F. Braun of Germany noticed that certain mineral substances could pass electrical currents. In Japan, Wichi Torikata investigated many minerals, such as **zincite**, **pyrolusite**, **iron pyrite** and **galena**.

Greenleaf W. Pickard, a member of the Wireless Specialty Apparatus Co. of Boston, also conducted extensive experiments and became well known for the PERIKON Detector, which employed zincite and **chalcopyrite**. General H.H.C. Dunwoody of the U.S. Army developed a **carborundum** detector. Until **radio** broadcasting began in 1920 at Station KDKA, Pittsburgh, the U.S. Navy and other maritime services utilized the crystal detector for **radiotelephone communications** and for reception of certain **Morse code** signals.

Modern sets no longer use crystals. Instead, they use **diodes**, which were developed from radar technology used during World War II. The basic principle remains the same — to remove the audio (speech, music or

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Morse code) from the radio frequency **carrier wave**. Your Crystal Radio Set uses a **Germanium** diode.

BASIC ELECTRONIC SYMBOLS

Explanation of components

Variable Capacitor — used to tune the radio to a station. The leads that are soldered to the lug connect it to the circuit.

Diode — a small crystal is sealed inside with the leads connected to it. Electricity moves only in one direction through the diode.

Coil — (radio-tuning coil) made by winding enameled copper wire around a plastic core 80 times. The leads have been stripped and **tinned** so they can be connected to the circuit.

Earphone — contains a small crystal that can make enough electricity to drive a metal **diaphragm** to produce **sound**. The leads have been stripped and tinned so they can be connected to the circuit.

Antenna — used for transmitting or receiving radio waves.

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Ground ⏚ G — used to make an electrical connection with the earth or another type of grounding source and create a common return for an electrical circuit.

See "UNDERSTANDING RADIO TECHNOLOGY" on Page 21 to learn more about these components and how they work together.

To put the Crystal Radio Kit together, read on!

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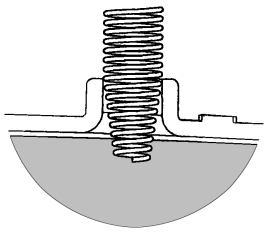
MAKING THE CONNECTIONS

Inserting the Spring Connectors

Hint: It is important to assemble the parts correctly. Half the fun is in knowing that you made your own radio! So, carefully read and follow these instructions step by step.

1. Locate the three spring connectors.
2. Insert each spring connector, narrowed end first, into one of the three holes on the base.

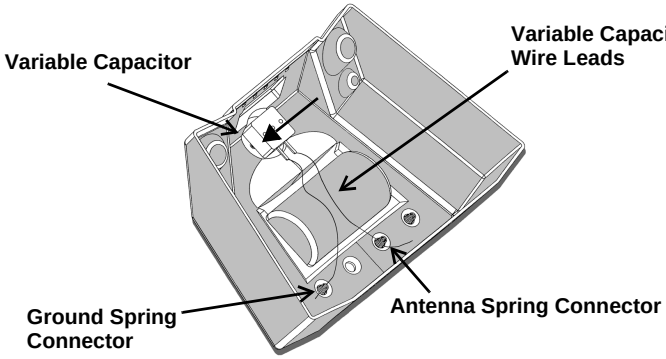


3. Push down on each spring connector and twist it to the right (clockwise) until the connector is about half way through the base.

Hint: Check to see if the spring connector is inserted halfway through the base by turning the base upside down.

Connecting the Variable Capacitor

You will need the variable capacitor, the two smaller screws, and a Phillips screwdriver for this connection. Be careful not to lose the small screws when you are putting the radio together.



1. Turn the base upside down.
2. Place the variable capacitor (as shown) in the base so the three holes on the capacitor line up with the three holes on the base.

Hint: When you do this, be sure the wire leads face inward (towards the coil well), and the rectangular lug faces upward.

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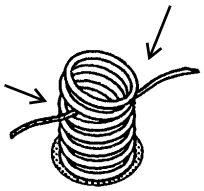
3. Hold the variable capacitor in place and turn the base right-side up.
4. Insert the two smaller screws into the smaller holes on top of the base and tighten them with a Phillips screwdriver.
5. Turn the base upside down and connect one wire to the antenna spring connector by bending the spring slightly to one side so the wire makes connections on both sides of the spring (as shown).



6. Connect the other wire to the ground spring connector in the same manner.

Hint: Do not connect any of the wires to the diode spring connector, otherwise your Crystal Radio will not work properly.

Connecting the Tuning Knob

You will need the tuning knob, the larger screw, a Phillips screwdriver, and the screw cap for this connection.

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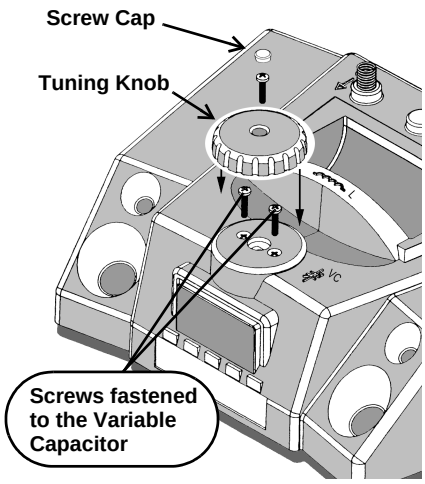
1. Make sure the base is right-side up. Place the tuning knob into position on top of the rectangular lug on the variable capacitor.
2. Insert the larger screw into the hole in the knob and tighten the screw with a Phillips screwdriver.
3. Place the screw cap over the screw and press down until the cap is flush with the tuning knob.



Connecting the Radio Coil

1. Press the coil down into the well until the coil clicks into place.
2. Connect one of the coil wires to the ground spring connector by bending the spring connector.
3. Connect the other coil wire to the antenna spring connector in the same way.

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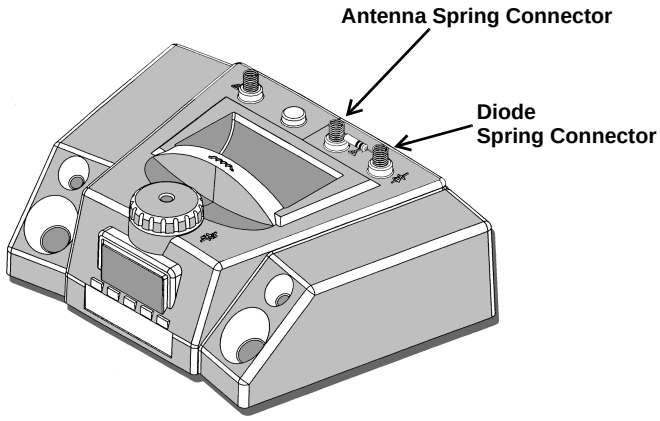
Attaching the diode

Insert the black striped end of the diode into the diode spring connector, and insert the other end into the antenna spring connector.



Hint: Make sure that the black stripes face toward the diode spring connector.

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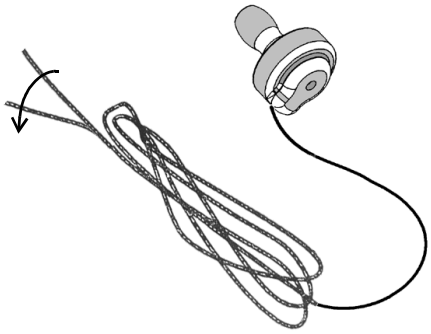
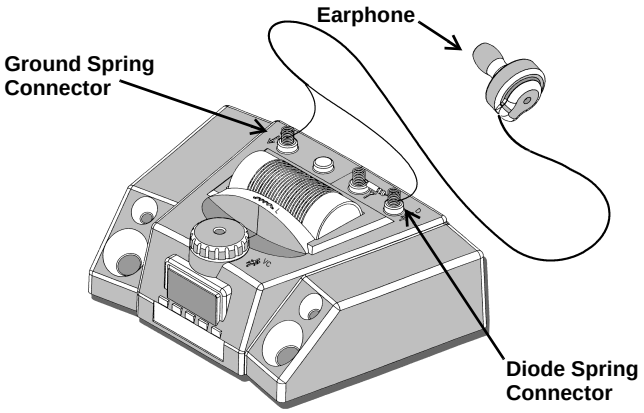
ATTACHING THE EARPHONE

1. Unwind the end of the earphone's wire about two inches so there are two wire leads.



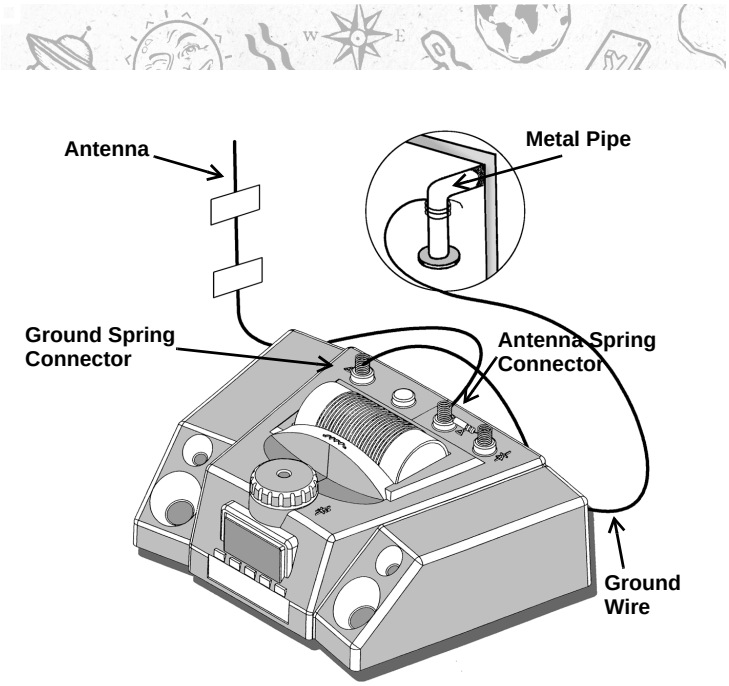
2. Attach one wire lead to the ground spring connector and the other to the diode spring connector.



Connecting the Antenna and Ground Wires

Note: For clarity, the earphone connection is not shown in this step.

1. Locate the red ground and the yellow antenna wires.
2. Attach the stripped end of the yellow antenna wire to the antenna spring connector.



Caution: The antenna should be placed in a straight line, away from power lines, electrical cords, and large metal objects. We suggest taping it up high on a wall using masking tape (as shown).

3. Attach the short, stripped end of the ground wire to the ground spring connector.

4. Attach the long stripped end of the ground wire to a metal cold water pipe, metal radiator pipe, or another metal pipe, near where the radio will be used.

Caution: Some pipes may be hot, so ask an adult to help you with this part of the project.

Hint: If there is not enough stripped, bare wire to wrap around a pipe, ask an adult to strip more insulation off the end using a pair of wire strippers.

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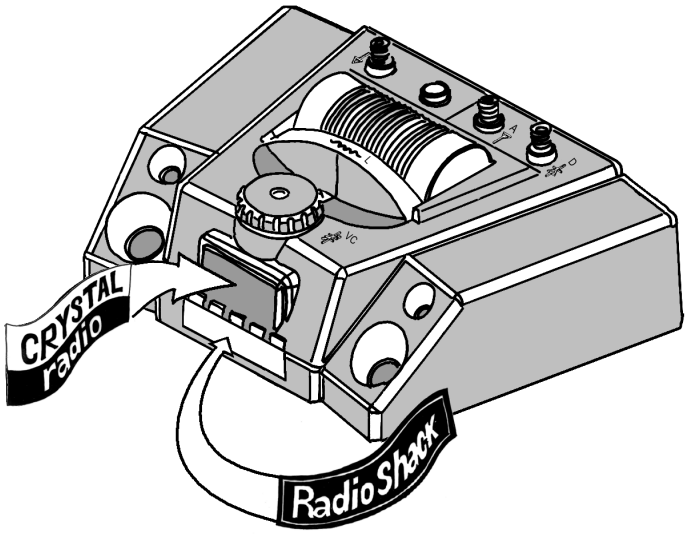
Attaching the Stickers

Peel off the paper backing and place the stickers on your radio as shown here.



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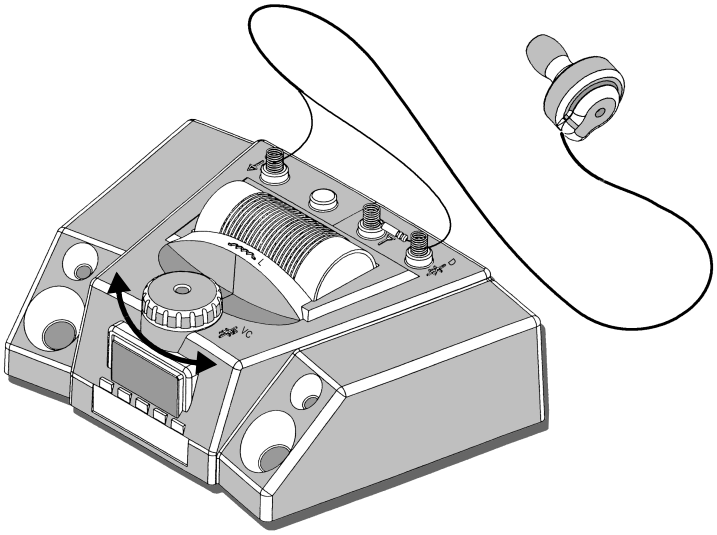
OPERATION

Once you have assembled the Crystal Radio, place the earphone in your ear and turn the tuning knob back and forth, until you pick up the strongest signal.



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TROUBLESHOOTING

If your radio does not pick up a strong signal, or if you do not hear anything, these suggestions might help you figure out the problem and fix it. If your radio still does not operate properly, take it to your local RadioShack store for assistance.

Radio does not work.	Check all the spring connectors to make sure the wires are attached correctly and that none of the wires are loose.
	Make sure that the loose end of the antenna wire does not touch any other connection.
Ground wire does not make a good connection.	Try taping the wire to the shiny part of a pipe using duct tape. If the pipe is dull or rusty, use sandpaper to gently sand the area where the wire makes contact.
	Make sure the wire does not touch anything other than the ground connection, or the radio might not work properly.

	Try using a ground rod (RadioShack Cat. No. 15-530) for a better ground connection. Be sure to follow the direction provided with the ground rod.
Reception is poor.	Make sure the antenna wire is stretched out as long as it can be and is as high above the ground as possible. Set the radio up on the highest floor where you live.
	Try placing the antenna wire in different positions (both vertically and horizontally) for the best reception.
	Insulated hook-up wire makes a very good substitution for the supplied antenna. Make sure the wire is at least 15 feet long.

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UNDERSTANDING RADIO TECHNOLOGY

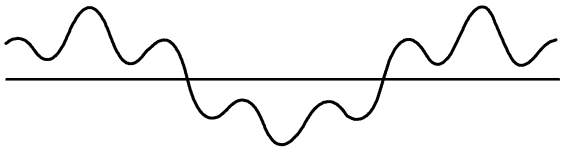
Now that you have your Crystal Radio kit together and working, it is time to take a brief look at how it works. To do this, we will take an imaginary trip to a radio station, WXWZ, in Anytown, USA.

When you get to the imaginary radio station, the station's general manager, Mr. Jones, meets you to show you around.

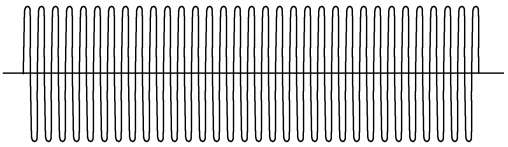
Mr. Jones takes you to a studio, which is where radio programs come from. There are a lot of dials and switches and equipment, including CD players, microphones, and hundreds of CDs. Mr. Jones lets you talk into the microphone.

When you talk into one of the microphones, your words go into the station's electronic equipment. From there, your words are mixed with the station's carrier wave and then sent out into the air through the station's transmitting antenna (the tall tower you saw on top of the radio station building). Mr. Jones then draws you a diagram to show you what happens to the sound of your voice. All energy travels

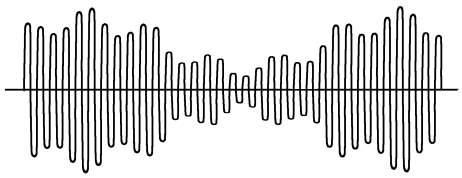
in waves, and since the sound we make when we talk is a form of energy, it might look something like this:



The station's carrier wave is also a **radio wave**, which looks something like this:



The **transmitter** combines the two different energy waves, creating a broadcast signal wave, which looks like this:



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The modulated wave is a signal. Each of the waves is the same length, but their heights vary. The height of the wave is called its **amplitude**. The type of transmission that WXWZ uses is called **amplitude modulation** (AM). That's why WXYZ is called an AM station.

The crystal radio that you built works in just the opposite way from the radio station. The modulated signal that is broadcast by station WXWZ is received by the antenna on your radio.

The antenna is connected to the **tuner circuit** of the radio (the coil of wire and the **variable capacitor** connected together). As you move the tuning knob, you are able to select, or isolate, the particular **frequency** that a station uses to broadcast its signal.

This signal is then **demodulated** by the diode, separating the audio (voice) wave from the carrier wave. The audio wave then moves to the earphone, where it is changed back into sound waves that you can hear.

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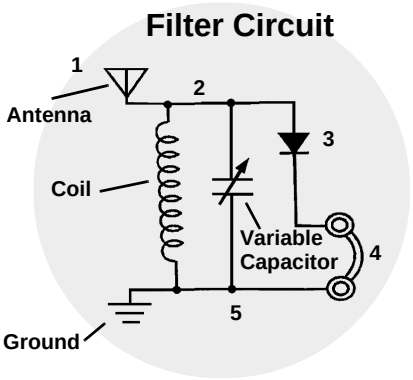
Here is a typical wiring diagram and explanation of how your crystal radio works.



1. The antenna receives signals from the air.
2. The tuner circuit, which includes the coil and the variable capacitor, selects a tuning frequency, filtering out other frequencies.
3. The diode passes the signal in one direction.
4. Sounds flow into the earphone.
5. The electrical current goes back to ground.

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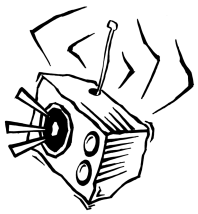
FACTS ABOUT RADIO



You probably listen to a radio nearly every day, but what exactly is it that you hear? Radio waves are sounds that are changed into electricity and sent out through air or space. We can pick up a tiny part of that electricity with a radio, which lets us hear the sounds. How does this work? Let's start out with a brief history of the radio.

Gugliemo Marconi

Most people give credit for building the first successful radio to an Italian inventor named Gugliemo Marconi, who built on the work of other scientists. In 1895, he sent telegraph signals — dots and dashes — through the air. Marconi realized that electricity not only can travel through wires, but it can also travel through space. His invention became known as "the **wireless**." (Even though a radio is full of electrical circuits and wires, there are no wires between radios, so they were called "wireless.")

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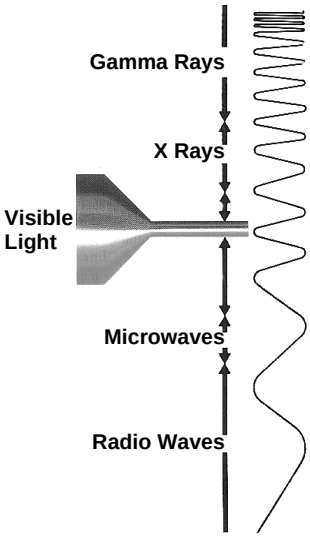
What did Marconi do that was so new? He made an electrical current change its direction very quickly. He knew that an electrical current generates a **magnetic field**, and by changing the electrical current's direction very quickly, he made waves in the magnetic field. These waves are very similar to **light** waves, only longer.



This type of wave is called an **electromagnetic wave** because an electromagnetic force generates it. **Electromagnetic energy** leaves its **source** in straight lines and is called **radiation**. Light and radio waves are different forms of electromagnetic radiation. The main difference between light waves and radio waves is their frequency. A radio wave frequency is much lower than a light wave frequency, which means that radio wavelength is longer than light wavelength.

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So, how long are radio waves? For a typical AM radio station, they are about 300 meters (328 yards) long. These waves travel with the speed of light. It takes less than one millionth of a second for the whole wave to go by you.

One way to think of an **electrical field** is to imagine a spray nozzle spraying a very fine mist into the air. If you are standing *near* the nozzle, the mist is thick, and you might get pretty wet. If you are standing *farther away* from the nozzle, the mist will be more spread out. Notice that even though the field of mist has different strengths, depending on the distance to the source, the mist is still moving *away* from the spray nozzle.

Electrical fields are similar: the *closer* you are to the source of a field (such as a radio broadcast tower), the stronger the field. When you are farther away, the field is more spread out. Also, the intensity or strength of the field differs as you move around it, and it moves *away* from its source.

In the 1890s, Marconi realized that in order to send an electrical field through the air (a radio wave), you have to have electricity that changes direction very quickly. This is called oscillating.

If you think about it, when you see something that is oscillating, it appears to be moving like a wave. If you are sit-

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ting in a boat, you feel the waves go past you and under you, and you **oscillate** up and down as a result.

Marconi realized that if electricity oscillates fast enough, energy will go into a wire (like an antenna) and right off into space or air. Then, if everything is set up right, you can use another antenna to capture just a tiny amount of that energy from the air and get information from it. That is what the wireless radio is all about. That energy is what we call a **radio wave**.

These days you see various types of antennas everywhere. There is one on almost every car, there is usually one on your television, and radios have one. An antenna sometimes has a special shape, but basically it is an electrical conductor that is connected to an **oscillator** and is free to broadcast or to receive electromagnetic signals out of or into the air.

In 1837 a painter named Samuel F.B. Morse thought about electrical circuits and designed a way to send information along a wire. He invented what is now called the telegraph. It could send messages as far as the wire could be strung.

The idea behind sending information with a telegraph is to make signals using a small metal magnetic lever. Every time you push the lever down, it completes an electrical circuit and a lever in another city is pulled down by magnetism.

That makes what is called a "click." There are two kinds of clicks: long (dashes) and short (dots). Normally, a dash is about three dots long. With one click being three times the length of the other, you seldom confuse the two. Morse came up with the standard information code that people are still using today. He assigned particular sets of clicks for all of the letters and numerals called the Morse code.

You do not have to use an electrical telegraph to send Morse code messages; you can make these signals with light, sound, squirts of water, or smoke. It takes practice to get to a point you can understand them.

International Morse Code				
. = dot		**_ = dash**		
A . _	B _ . . .	C _ . _ .	D _ . .	E .
F . . _ .	G _ _ .	H	I . .	J . _ _ _
K _ . _	L . _ . .	M _ _	N _ .	O _ _ _
P . _ _ .	Q _ _ . _	R . _ .	S . . .	T _
U . . _	V . . . _	W . _ _	X _ . . _	Y _ . _ _
Z _ _ . .				

Numbers				
1 . _ _ _ _	2 . . _ _ _	3 . . . _ _	4 . . . . _	5 . . . . .
6 _	7 _ _ . . .	8 _ _ _ . .	9 _ _ _ _ .	0 _ _ _ _ _

Other Signals			
Period (.) . _ . _ . _	Comma (,) _ _ . . _ _	? . . _ _ . .	Error . . . . .
$ . . . _ . . _	Start Signal _ . _ . _	End of Message (EOM) . _ . _ .	Wait . _ . . .
Understood . . . _ .	Interrogatory/ Question . . _ . _	Emergency Silence . . . . _ _	Break-In _ _ _ _ _
Distress Signal Relay _ . . _ . . _ . .	Help (SOS) . . . _ _ _ . . .	End of Work . . . _ . _	= _ . . . _

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GLOSSARY

amplitude — height of a radio wave from a base line

amplitude modulation (**AM**) — a system of varying a radio signal's amplitude in order to put the signal on a carrier wave

antenna — a device used to send or receive electromagnetic waves

carborundum — a silicon carbide abrasive, often used as the crystal in early crystal detectors

carrier wave — electromagnetic wave or alternating current whose modulations are used as signals in radio and TV

chalcopyrite — copper-iron sulfide, often used as the crystal in early crystal detectors

crystal detector — a mineral or crystal material that allows electrical current to flow more easily in one direction than in the other

crystal diode — a semiconductor with two electrodes or terminals

current — a flow of electrical charge; movement of electricity through a conductor

demodulate — to pull out information from a modulated carrier wave

diaphragm — a thin disk that vibrates in response to electrical signals to produce sound waves

diode — a two-terminal semiconductor that restricts current flow mainly in one direction

earth ground — a connection from an electrical circuit to the earth through a water pipe or a metal rod driven into the earth

electrical field — an area in which an electrical force occurs

circuit — the complete path of an electrical current, including the source of electrical energy

electromagnetic energy — forms of radiant energy such as radio waves, light waves, heat waves, X-rays, gamma rays, and cosmic rays

electromagnetic wave — radiant energy produced by oscillation of an electrical charge

frequency — number of electromagnetic waves that pass a certain point in a given period of time

frequency modulation (**FM**) — a system of varying a radio signal's frequency in order to put the signal on a carrier wave

galena — lead sulfide, used as the crystal in early crystal detectors

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germanium — metalloid (Ge) number 32 in the Periodic Table of Elements

iron pyrite — often used as the crystal in early crystal detectors

light — visible radiant energy transmitted by wave motion

magnetic field — a force that exists around an electrical current

modulate — to vary the frequency or amplitude of an electromagnetic wave

Morse code — a code for the alphabet using a series of long and short signals

oscillate — to swing back and forth steadily

oscillator — a device that generates alternating current or power

pyrolusite — often used as the crystal in early crystal detectors

radiation — giving off electromagnetic energy

radio — communication of audible signals encoded in electromagnetic waves

radio wave — an electromagnetic wave within the range of radio frequencies

radiotelephone communications — two-way transmission and reception of sounds by radio

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signal — the sound or image conveyed in telegraphy, telephony, radio, radar, or TV

sound — vibrating waves in the air, capable of being heard

source — the device which supplies signal power

tinned — process to treat a wire by stripping the insulation and coating the wire with solder

transmitter — a device that converts one type of signal (sound waves) into another type of signal (electromagnetic waves) and sends it out to a receiver

tuner circuit — a circuit used to select signals of a particular frequency for conversion

variable capacitor — used to tune the radio to a station by storing electrical energy, blocking the flow of direct current, while allowing the flow of alternating current (of a particular frequency)

wireless — a radiotelegraph system

zincite — zinc-oxide, often used as the crystal in a crystal detector

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NOTES

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Cat. No. 28-178

Limited Ninety-Day Warranty

This product is warranted by RadioShack against manufacturing defects in material and workmanship under normal use for ninety (90) days from the date of purchase from RadioShack company-owned stores and authorized RadioShack franchisees and dealers. EXCEPT AS PROVIDED HEREIN, RadioShack MAKES NO EXPRESS WARRANTIES AND ANY IMPLIED WARRANTIES, INCLUDING THOSE OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO THE DURATION OF THE WRITTEN LIMITED WARRANTIES CONTAINED HEREIN. EXCEPT AS PROVIDED HEREIN, RadioShack SHALL HAVE NO LIABILITY OR RESPONSIBILITY TO CUSTOMER OR ANY OTHER PERSON OR ENTITY WITH RESPECT TO ANY LIABILITY, LOSS OR DAMAGE CAUSED DIRECTLY OR INDIRECTLY BY USE OR PERFORMANCE OF THE PRODUCT OR ARISING OUT OF ANY BREACH OF THIS WARRANTY, INCLUDING, BUT NOT LIMITED TO, ANY DAMAGES RESULTING FROM INCONVENIENCE, LOSS OF TIME, DATA, PROPERTY, REVENUE, OR PROFIT OR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, EVEN IF RadioShack HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Some states do not allow the limitations on how long an implied warranty lasts or the exclusion of incidental or consequential damages, so the above limitations or exclusions may not apply to you.

In the event of a product defect during the warranty period, take the product and the RadioShack sales receipt as proof of purchase date to any RadioShack store. RadioShack will, at its option, unless otherwise provided by law: (a) correct the defect by product repair without charge for parts and labor; (b) replace the product with one of the same or similar design; or (c) refund the purchase price. All replaced parts and products, and products on which a refund is made, become the property of RadioShack. New or reconditioned parts and products may be used in the performance of warranty service. Repaired or replaced parts and products are warranted for the remainder of the original warranty period. You will be charged for repair or replacement of the product made after the expiration of the warranty period.

This warranty does not cover: (a) damage or failure caused by or attributable to acts of God, abuse, accident, misuse, improper or abnormal usage, failure to follow instructions, improper installation or maintenance, alteration, lightning or other incidence of excess voltage or current; (b) any repairs other than those provided by a RadioShack Authorized Service Facility; (c) consumables such as fuses or batteries; (d) cosmetic damage; (e) transportation, shipping or insurance costs; or (f) costs of product removal, installation, set-up service adjustment or reinstallation.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

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